(54) Title: A METHOD AND A SYSTEM IN A CELLULAR NETWORK
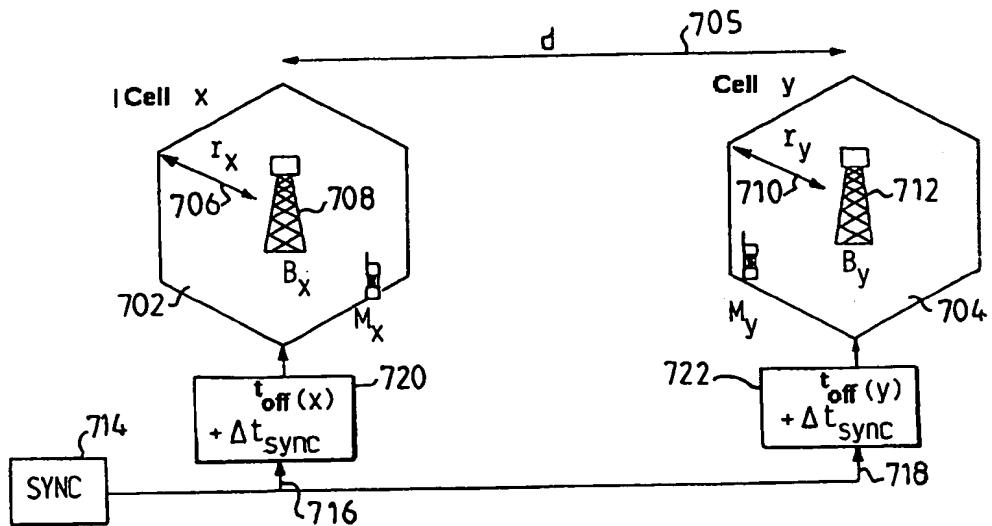
(57) Abstract

In a cellular mobile radio system, co–channel radio base stations are provided with a time reference signal being a synchronizing signal or a time reference from another co–channel radio base station. Each co–channel radio base station (708, 712) is also provided with a radio base station specific time offset (720, 722) differing between the co–channel radio base stations by at least a predetermined value which prevents known sequences in desired signals and known sequences in interfering signals from overlapping in a disturbing way at reception. In each co–channel radio base station the time reference signal and the radio base station specific offset are used for the timing of sending bursts downlink from the co–channel radio base stations towards mobile radio stations. Each radio base station has functions receiving the time reference signal, storing the time offset and using the time reference signal and the time offset for the timing of the burst termination on the downlink (720).

A method and a system in a cellular network.

Technical Field of the Invention.

The present invention according to first and second
aspects generally relates to a method and a system,
respectively, for counteracting interference between cells in a
cellular mobile radio system including a plurality of radio base
stations and mobile radio stations. More particularly, the radio
base stations are of the kind using, as units of transmission,
bursts organized in groups, each group forming a frame of the
type used by a Time Division Multiple Access TDMA system, and
each burst containing a known sequence of data bits. At least
two of the radio base stations are supposed to be co-channel
radio base stations employing a same frequency. According to a
third aspect the invention also relates to a radio base station
for use in a cellular mobile radio system of the kind mentioned.

Description of Related Art.

There are a number of publications teaching
synchronization of the point of time for sending information
(e.g. time slots, frames, training sequences) so as to increase
the correlation between the cells (or the radio transmitters).
This is true e.g. in "simulcast" systems and in systems offering
macro diversity (e.g. CDMA systems). US 5,206,855 and US
4,972,507, to be dealt with in some more detail below, describe
systems wherein transmission of time slots is planned so as to
avoid that cells/stations located close together send
simultaneously and on the same frequency.

US 5,206,855 discloses transmission of messages in a
system using several frequencies. The messages are transmitted
sequentially in such a way that messages from one cell are not
transmitted simultaneously with transmission from another cell.

US 4,972,507 relates to a method for transmitting data
between the base station and the user unit in a mobile telephony
system. All user units in a cell are interrogated by the base
station transmitting an interrogation signal. The user units
respond by sending a short message where each unit has a unique

delay for avoiding that messages interfere.

US 5,473,612 discloses how to decrease the risk for erroneous detection of a data packet in a radio communication system. The described invention is based upon the fact that packets from different stations have different delay. At reception from a certain station the synchronization sequence is searched in a time window corresponding to the delay of said station.

WO 95/35,601 discloses a method for minimizing interference from surrounding cells by using four different frequencies and directional antennas.

WO 95/17,048 discloses a radio telephony system where "co-channel interference" is reduced by assigning channels dependent on the position of the mobile unit and controlling the output power so as to make mobiles located within border areas to send with a lower power.

WO 94/30,024 describes a method for synchronizing two base stations in a CDMA system. The purpose of the synchronizing is to obtain so-called "macro diversity".

Further publications showing a more general stand of the art are US 4,642,806, EP 208,021, DE 29,43,115, WO 95/08,901, US 5,124,698 and US 5,509,016.

Background of the Invention.

Below a number of aspects within the so-called GSM-system will first be dealt with. To the extent that some of these aspects are only mentioned below, without being described in detail, reference can be made to "The GSM System for Mobile Communications, A comprehensive overview of the European Digital Cellular Systems", by Michel MOULY and Marie-Bernadette PAUTET, also being publishers, International Standard Book No. 2-9507190-0-7.

In high traffic areas, such as large cities, the capacity of a cellular system is limited by its own interferences caused by frequency reuse. The relative interference ratio, expressed as C/I, where C is the Carrier level and I is the Interference level, may vary a lot between calls. C changes with the mobile station position relative to the base station, with the amount of obstacles between them, etc.; I changes depending on whether

the frequency is being used by another call in some nearby cell, and it also varies according to the distance to the interfering source, its level, etc.

A basic concept of the GSM transmission on the radio path is that the unit of transmission, called burst, is a series of e.g. about 150 modulated bits. The GSM bursts are organized in groups of 8, such a group being referred to as a TDMA frame (TDMA - Time Division Multiple Access). Bursts have a finite duration, and occupy a finite part of the radio spectrum. They are sent in time and frequency windows, or slots. Precisely, the central frequencies of the slots are positioned every 200 kHz within the system frequency band (FDMA aspect), and they recur in time every 0,577 ms, or more exactly, every 15/26 ms (TDMA aspect). All slot time limits regarding different carrier frequencies are simultaneous in a given cell.

Within the time interval of a time slot, the amplitude of transmission rises from a starting value of 0 to its nominal value. The signal phase is modulated to transmit a packet of bits. After that, the amplitude decreases until it reaches 0.

The packet of bits used to modulate the signal phase of a burst includes a training sequence besides the variable part of the information, plus "0" bits at each end. The training sequence is a sequence of 26 bits known by the receiver. The signal resulting from the transmission of this training sequence allows the receiver to determine very precisely the position of the useful signal inside a reception time slot, and to have an idea of the distortion caused by transmission. These informations are of prime importance to obtain good demodulation performance.

There are several such training sequences defined in GSM. Thus, eight different training sequences have been specified.

One of the purposes of using training sequences is to obtain equalization.

If two signals, one desired and one interfering, arrive at a receiver at almost the same time, and their training sequences are the same, there is, in conventional receivers, no way to distinguish the contribution of each of them from the received signal. The situation is much clearer when the two training sequences differ, and are as little correlated as

possible. Distinct training sequences are therefore allocated to
channels using the same frequencies in cells which are close
enough to interfere with one another.

The eight training sequences have been chosen for the
special shape of their autocorrelation function, which is meant
to ease some demodulation techniques.

Summary of the Invention.

When planning a GSM mobile telephone network, one of the
issues is normally the frequency planning, i.e. the distance
between frequency reuse, and how to place different frequencies
for fulfilling the capacity and coverage requirements. One
limiting parameter for the planning is the distance to the
closest co-channel interferer, i.e. the distance to the cells
employing the same set of frequencies.

A frequency reuse scheme is basically described by the
frequency reuse factor, $K=g/n$. This parameter describes how the
available frequencies are distributed in the network. More
particularly, g indicates the number of sites in a cluster of
cells containing all available carrier frequencies, and n is the
number of sectors in the cluster.

Today many new techniques are being studied and
implemented, which make the desired signal less sensitive to co-
channel interference, and thereby make it possible to reduce the
reuse distance. These techniques are for instance Slow Frequency
Hopping (SFH), Discontinuous Transmission (DTX), Power Control
(PC), as specified in the GSM specifications. Other techniques,
which are compatible with GSM, have been suggested, as e.g.
smart antennas, distributed antennas etc. It may be expected
that improved techniques make frequency reuse factors as $K=1/1$
or $K=1/3$ realistic.

As only a limited number of different training sequences
are available, a new problem will occur; the closest co-channel
interference which employs the same training sequence will come
in sight of the receiving unit, i.e. base or mobile station.
Below and further on there will be used a new expression "co-
sequence interference" for co-channel interference which employs
the same training sequence.

The problem occurs, if the co-sequence interfering base

stations have a timing of the TDMA-frame, which involves that
the training sequence from the co-sequence interferer overlaps
the training sequence from the desired transmitter.

A similar problem can, however, also appear for co-
channel cells having different training sequences but involving
undesired cross-correlation effects.

Therefore, it is an object of the present invention to
provide a method and apparatus for counteracting co-sequence
interference and co-channel interference due to undesired
correlation effects, in digital cellular mobile radio systems,
in particular those of TDMA type, but also those of CDMA type
when including TDMA timing subdivision.

According to the first and second aspects referred to by
way of introduction, this object is achieved by an inventive
method and apparatus, respectively, providing at least two co-
channel radio base stations with a time reference signal and
with a radio base station specific time offset differing between
the co-channel radio base stations by at least a predetermined
value which prevents known sequences in desired signals and
known sequences in interfering signals from overlapping in a
disturbing way at reception. In each co-channel radio base
station the time reference signal and the radio base station
specific offset are used for the timing of sending bursts
downlink from the co-channel radio base stations towards mobile
radio stations.

According to the third aspect, the object is also
achieved, in a system of the kind referred to, by a radio base
station comprising means for receiving the time reference
signal, means for storing the radio base station specific time
offset, and means for making use of the time reference signal
and the radio base station specific offset for the timing of
sending bursts downlink from the co-channel radio base stations
towards mobile radio stations.

An advantage obtained with the present invention is that
the offset allows the receiver to receive the wanted line of
sight signal and also reflected signals if an equalizer is used
in the receiver while rejecting co-channel signals because they
have a time offset above a predetermined value.

A further advantage is the reduced disturbance. This may

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be used either for obtaining better quality i.e. improved carrier-to-interference ratio C/I, or increased traffic handling capacity.

        Brief Description of the Drawings.
        The invention will now be described more closely below with reference to the drawings, on which
        Fig. 1 schematically illustrates a cellular GSM network part structure to indicate how the beam pattern of an antenna array might be formed when a strong co-sequence interference is present, as the beam pattern is optimized for the training sequence used in a cell,
        Fig. 2 schematically shows three bursts to indicate when a co-sequence interference signal could be percepted as a desired signal component when received in the same receiving unit in a network structure of the kind indicated by Fig. 1,
        Fig. 3 schematically illustrates the structure of a training sequence arranged so as to provide good auto-correlation properties,
        Fig. 4 schematically illustrates the geometry of two co-sequence interfering cells to show some important parameters,
        Figs. 5 and 6 are curve diagrams illustrating simulations of a MRC algorithm and an IRC algorithm, respectively, to illustrate the difference between co-channel and co-sequence interference,
        Fig. 7 shows an embodiment of the present invention indicating means for reducing correlated co-channel and co-sequence interference,
        Fig. 8 is a graphical view indicating the influence of the parameters illustrated by Fig. 7, and also serving as a tool for finding a parameter value that avoids critical co-sequence interference,
        Fig. 9 schematically indicates a cellular network structure with all frequencies reused in all cells, and eight different training sequences being used to distinguish between signals from different cells,
        Fig. 10 shows the geometry of a layer of one of the training sequence layers, included in the structure according to Fig. 9,

Fig. 11 is a table indicating, for cells of a cellular network, linking of the cells to a number of potential co-sequence interferers and their parameters,

Fig. 12 is a graph showing the relationship between cells included in the table of Fig. 11, and more particularly between one of these cells and a number of the other cells being co-sequence cells,

Fig. 13 is a graph similar to that of Fig. 12, showing the timing relationship for the cell illustrated by Fig. 12 when one co-sequence cell is shifted in time,

Fig. 14 is a table providing examples of possible co-sequence and cross-correlation interference regions found between cells of a cellular network,

Fig. 15 shows a cellular network structure for indicating cells that may contribute with a sufficiently high power to cause correlation problems,

Fig. 16 shows a cellular network structure similar to that of Fig. 15, but indicating only cells having undesired correlation effects, i.e. co-sequence or cross-correlation effects.

Fig. 17 is a schematical block diagram of a radio base station for use in a cellular mobile radio system according to the invention.

Detailed Description of Embodiments.

Fig. 1 illustrates the beam patterns of an antenna array in a cellular TDMA network when a strong co-sequence interference is present between two of the network's cells, i.e. two cells employing the same frequency and the same training sequence.

More particularly, Fig. 1 shows a GSM network part structure including five cells 102, 104, 106, 108 and 110, the cells 102 and 110 being separated from each other by the cells 104, 106 and 108. The base stations of cells 102 and 110 are indicated at 112 and 114. The cells 102 and 110 are using the same training sequence, as well as employing the same frequencies. It is therefore the question of possible co-sequence interference between the base stations 112 and 114, as will be explained below. The base stations of the cells 104, 106

and 108 have training sequences being different both mutually
and with respect to the cells 102 and 110.

A mobile station 116 located in the cell 102 emits bursts
to the network received by the base station 112 and resulting in
a small narrow beam pattern 118 being formed towards the mobile
station 116. Simultaneously, another mobile station 120 located
in the co-sequence interfering cell 110 also emits bursts to the
network received by the base station 114 and resulting in a beam
pattern 122.

The bursts of the mobile station 120 are also, however,
intercepted by the base station 112 and perceived as if they
were desired bursts from the user 116. The base station 112
therefore perceives the co-sequence interference as a desired
signal component and will amplify the interfering signal from
the mobile station 120, this being indicated by a beam pattern
124.

Fig. 2 illustrates a situation in which a co-sequence
interference signal could be percepted as a desired signal
component when received in the same receiving unit, e.g. the
base station 112 in Fig. 1. More particularly, there are shown
three received bursts 200, 202 and 204, respectively.

The bursts 200 and 202 are supposed to be a desired
signal and a co-sequence interference signal, respectively, as
e.g. arriving from the mobile stations 116 and 120,
respectively, as discussed above with reference to Fig. 1. The
burst 204 is supposed to be an alternative co-sequence
interference signal and has been introduced in Fig. 2 for the
purpose of further explanation. The three signals partially
overlap along a time axis, not shown.

As is conventional, each burst has two packets of
information surrounding a training sequence. Thus, the
information packets and training sequence of the burst 200 are
indicated at 206, 208 and 210, respectively. The bursts 202 and
204 are similarily structured as shown.

The partial overlapping between the burst 200, on the one
hand, and the bursts 202 and 204, on the other hand, results in
misalignments between the training sequence 210 of the burst 200
and the respective training sequences of the bursts 202 and 204.
The misalignment between the training sequence 210 of the

desired burst 200 and that of the co-sequence interfering burst
202 is denoted Δt_{202}. The misalignment between the training
sequence 210 and that of the co-sequence interfering burst 204
is denoted Δt_{204}. In Fig. 2 there is also shown a region 212
extending on both sides of the left hand end of the training
sequence 210. This region 212 indicates a critical misalignment
denoted $\Delta t_{critical}$ to each side of the left hand end of the training
sequence 210.

As will be described more closely further on, a
misalignment, such as the misalignments Δt_{202} and Δt_{204} between
the training sequences of the co-sequence interfering signals
202 and 204, has to be more than the value $\Delta t_{critical}$ to ensure that
co-sequence effects will not occur. As indicated in Fig. 2, Δt_{202}
is less than $\Delta t_{critical}$, whereas Δt_{204} is greater than $\Delta t_{critical}$,
meaning that co-sequence effects may occur in the case of the
burst 202 but not in the case of the burst 204.

In case there would be complete overlap between a desired
signal and a co-sequence interfering signal, and thus no
misalignment, then Δt for an interfering signal would be equal
to $0\ T_s$, meaning that the two bursts would be synchronized at the
receiving unit. T_s designates a symbol time to be used henceforth
when explaining different aspects of the invention.

The problem of having co-sequence interference, is that a
number of features in the base and mobile station exploit the
training sequence, in order to estimate the radio channel and in
order to distinguish the desired signal components from the
interfering components. Some of these features, being wellknown
to those of ordinary skill in the art, are
- Equalization
- Measurement reporting
- Diversity combining
- Timing adjustment
- Adaptive antenna functionalities (Uplink
combining, etc.)

In an extreme case, such as the one described above with
reference to Fig. 1, a base station can start to receive the
bursts of a co-sequence interference signal instead of the
desired signal. The timing functionality of the base station

will synchronize on the wrong mobile station in the cases where
the co-sequence interference is stronger than the signal from
the desired mobile. The diversity combining, equalization and
smart antenna combining algorithms will amplify the
interference, as the base station receives the desired training
sequence from the interference.

Below, transmission from a mobile station MS towards a
base station BTS will be referred to as "uplink", and
correspondingly transmission from a BTS towards an MS will be
referred to as "downlink".

The previously described problem of correlated
interference in the uplink direction can also appear in the
downlink direction as the mobile station also uses training
sequence code (TSC) dependent receiver algorithms.

As a background information, and with reference to "The
GSM System for Mobile Communications, A comprehensive overview
of the European Digital Cellular Systems", mentioned earlier
above, the timing relationship between uplink and downlink can
be described as follows.

As seen at the base station, the burst timing in the
uplink direction is derived from the downlink direction by a
delay of 3 burst periods, where each burst period has a value of
15/26 ms. This delay of nominally 3 burst periods is constant
throughout GSM.

However, the delay between sent and received bursts of
the mobile station is affected by the propagation delays which,
even at the speed of light, are not negligible compared to the
burst duration (the round-trip delay between an MS and a BTS 30
km apart is 200 μs).

When the mobile station is far from the BTS, propagation
delays cannot be neglected, and an exact 3 burst period shift
cannot be maintained both at the MS and at the BTS. It is,
however, imperative that the bursts received at the BTS fit
correctly into the time slots. Otherwise, the bursts from mobile
stations using adjacent time slots could overlap, resulting in a
poor transmission quality or even in a loss of communication.
The solution for this is that the mobile station advances its
emission relatively to its reception by a time compensating the
propagation delay. This value is called the timing advance, or

TA, which will be used as a parameter in connection with describing the invention further below. The exact shift between downlink and uplink as seen by the mobile station is then 3 burst periods minus the timing advance. The timing advance value can be computed by the BTS, and is then provided to the mobile station through signalling.

Two parameters are involved when considering whether co-sequence interference is a problem, viz. power level of the interference and timing between the transmissions of base stations.

If the power level of the received interference can be assumed to be under a predetermined value due to path loss, the interference problem can be disregarded. The same is the case if the training sequences do not overlap in time. The behaviour of the timing and the power will now be studied.

As regards timing between base stations there has, when defining the problem, to be distinguished between synchronized and non-synchronized networks. The structure of the training sequence is furthermore of importance. In GSM the training sequence consists of 3 different data entities A, B and C, arranged in five blocks in a way so as to have good auto-correlation properties. Thus, with reference to Fig. 3, the structure of the training sequence starts with a first block 302 of the data entity A followed by blocks 304, 306, 308 and 310 of the data entities B, C, A and B, respectively.

For non-synchronized networks, and assuming that the timing between base stations is uniformly random, it is possible to calculate that a significant probability for a co-sequence interference exists.

As regards a synchronized network, Fig. 4 illustrates three important parameters. In Fig. 4, two cells are indicated at 402 and 404, and their respective base stations at 406 and 408. The cells 402 and 404 are supposed to be co-sequence interfering. A first parameter is the distance $d-t_d$, indicated by double arrow 410, between the base stations 406 and 408. A second parameter is timing advance TA as described above. A third parameter is the "radius" $r-t_r$ of the cell 404, indicated by double arrow 412. The sign ~ indicates that distances d and r are related to their respective propagation times t_d and t_r by

the speed of light c, i.e. $t_d = d/c$ and $t_r = r/c$.

The propagation time t_r between the base station 408 and the cell border is assumed to be half of the maximum timing advance TA value. In Fig. 4, the timing advance TA lets the interfering signal come earlier to the co-sequence cell. The misalignment Δt, indicated by double arrow 414, is the same in base station 406 uplink and mobile station 416 downlink and amounts to $t_d - 2t_r$ in the example shown in Fig. 4, wherein the mobile 416 is supposed to be located near a border facing cell 402, and described more closely below.

The TA thus makes the co-sequence signal active earlier to the base station 406 in the cell 402 that uses the same training sequence. Suppose for example that the two co-sequence cells 402 and 404 have a distance between them of d = 10 km and that the cell 404 has a radius r = 4 km. In the cell 404 there is a mobile station 416 disturbing the cell 402. A problem will arise when the disturbing mobile 416 is close to the cell border facing the cell 402 as indicated in Fig. 4. In this case base station 406 will see the disturbing mobile with only d-2r = 2 km (corresponding to 1.8 Ts) offset, i.e. the co-sequence interference will be included as a desired signal in algorithms which exploit the training sequence.

The second important parameter, which has to be examined to show whether there is a problem, is the sensitivity when the co-sequence power is low, i.e. the path loss between co-sequence cells might remove the problem. In order to show this, two algorithms for antenna arrays and diversity reception in the art referred to as MRC (for Maximum Ratio Combining) and IRC (for Interference Rejection Combining), have been simulated with co-sequence interference.

The first simulation evaluates the MRC algorithm on sector antennas, which corresponds to the diversity system operating in GSM today.

Fig. 5 is a curve diagram showing the MRC algorithm on two branches, as a typical diversity base station works today. The upper curve indicates co-sequence interference and the lower one indicates co-channel interference. As can be seen, the performance is approximately 4 dB worse in the case of co-sequence interference. The training sequence code in this case

is TSC-no = 2 of the GSM system. The delay Δt is 0 T_S.

It may be expected that the path loss between co-sequence cells is significantly larger than the path loss between neighbouring co-channel cells. If the path loss of a co-sequence signal to the desired carrier is 4 dB more than that of a co-channel signal, the disturbing effect of co-sequence will be the same as that of co-channel. It might also be expected that path loss will reduce co-sequence interference significantly.

The second simulation evaluates an adaptive antenna system employing the IRC algorithm, with a result that appears from the curve diagram of Fig. 6. Delays of Δt = 0, 1, ... 5 T_S were tested, in order to study the dependency of Δt, the corresponding curves being shown in Fig. 6.

Fig. 6 indicates that the co-sequence interference 601 requires in the order of 30 dB better C/I than the ordinary co-channel interference 602. This indicates that even though the path loss is larger for co-sequence interference than for co-channel interference, the co-sequence interference can still degrade the system performance significantly.

Fig. 6 furthermore shows the degradation for different time offsets Δt between the base station and the co-sequence interfering mobile station. In the earlier with reference to Fig. 4 described example concerning synchronized base stations, the offset was 2 km corresponding to 1.8 T_S. As can be seen in Fig. 6 this involves an extreme degradation of the performance.

In a first step of action the above described problems of having co-sequence interference can be dealt with by putting constraints on the frequency planning. The co-sequence cells have to be separated sufficiently in order to obtain sufficient path loss or timing misalignment. The co-sequence can also be reduced by increasing the frequency reuse distance. However, this solution will degrade capacity.

According to a broad aspect of the present invention, co-channel radio base stations using the same training sequences, or those having different training sequences but cross-correlation effects, are provided with a time reference signal being a synchronizing signal or a time reference from another co-channel radio base station. Each co-channel radio base

station is furthermore provided with a radio base station
specific time offset differing between the co-channel radio base
stations by at least a predetermined value which prevents known
sequences in desired signals and known sequences in interfering
signals from overlapping in a disturbing way at reception. In
each co-channel radio base station the time reference signal and
the radio base station specific offset are used for the timing
of sending bursts downlink from the co-channel radio base
stations towards mobile radio stations.

The employed algorithms in the network are evaluated,
e.g. by simulation, in order to determine the base station
specific time offsets. Fig. 6 indicates for instance that when
the time offset is 4 Ts or more, the co-sequence interference
problem is significantly reduced. The optimization procedure is
iterative, corresponding to ordinary frequency planning.

In a further step of action the inventive base station
specific time offsets are exploited.

According to one embodiment of the invention, described
below with reference to Fig. 7, the base stations are first
synchronized and then an individual time-delay is inserted on
each base station, in order to eliminate/reduce the co-sequence
problem. The synchronization can be performed e.g. through a PCM
link or by GPS. The wide tolerance of the synchronization
accuracy allows a cheap/easy synchronization method.

In another embodiment, the offsets are adjusted at the
individual base station by monitoring correlated interference.

In Fig. 7 there are two co-sequence cells x and y,
indicated at 702 and 704, respectively. There is a distance d,
indicated by double arrow 705, between the co-sequence cells x
and y. The distance d is a first parameter to be used in a
geometrical procedure to be described later, and defines the
propagation time between the cells.

The cell x has a radius r_x, indicated by double arrow
706, and a base station B_x, indicated at 708. The cell y has a
radius r_y, indicated by double arrow 710, and a base station B_y,
indicated at 712. The radii r_x and r_y are a second parameter to
be used in the geometrical procedure.

In Fig. 7 there is also indicated a synchronization
functionality, indicated by a block 714, for synchronizing the

base stations 708 and 712, indicated by arrows 716 and 718,
respectively. For each of the cells 702 and 704 there is a
functionality, indicated by a respective block 720 and 722, for
adding a respective offset parameter $t_{off(x)}$ and $t_{off(y)}$, as well as
the tolerance $\pm\Delta t_{sync}$ of the synchronization functionality 714, to
the respective base stations 708 and 712. The offset parameters
$t_{off(x)}$ and $t_{off(y)}$ are used as adjustment means for avoiding the co-
sequence interference phenomenon. The tolerance $\pm\Delta t_{sync}$ takes into
account e.g. different lengths of cables between block 714 and
the radio base stations 708 and 712.

When adequate base station specific time offset is used
in individual base stations, the network avoids critical overlap
of equal training sequences. One co-sequence layer can be
planned independently of all others. The planning procedure will
therefore be illustrated for one layer only in an example to be
described later on.

With reference to the discussion with reference to Fig.
4, there can be set up the following equations defining the
maximum and minimum propagation times between the two cells 702
and 704, expressed as the misalignment Δt, as shown in Fig. 2,
between the respective training sequences of the co-sequence
interference signal and the desired signal. Uplink and downlink
are examined for both cells, which results in 4 sets of
equations.

Uplink, mobile station M_y to base station B_x,
$$min(\Delta t) = t_d + t_{off(y)} - t_{off(x)} - 2\Delta t_{sync} - 2t_{ry}$$
$$max(\Delta t) = t_d + t_{off(y)} - t_{off(x)} + 2\Delta t_{sync}$$

Uplink, mobile station M_x to base station B_y,
$$min(\Delta t) = t_d + t_{off(x)} - t_{off(y)} - 2\Delta t_{sync} - 2t_{rx}$$
$$max(\Delta t) = t_d + t_{off(x)} - t_{off(y)} + 2\Delta t_{sync}$$

Downlink, base station B_x to mobile station M_y,
$$min(\Delta t) = t_d + t_{off(x)} - t_{off(y)} - 2\Delta t_{sync} - 2t_{ry}$$
$$max(\Delta t) = t_d + t_{off(x)} - t_{off(y)} + 2\Delta t_{sync}$$

Downlink, base station B_y to mobile station M_x,

$$min(\Delta t) = t_d + t_{off(y)} - t_{off(x)} - 2\Delta t_{sync} - 2t_{rx}$$
$$max(\Delta t) = t_d + t_{off(y)} - t_{off(x)} + 2\Delta t_{sync}$$

The task is to adjust t_{off} for each cell with respect to
the critical co-sequence cells, so that Δt never is in a
critical region.

In order to illustrate the adjustment procedure, a
graphical method will be described here. The above eight
equations are included in a graphical overview according to Fig.
8, which can be used for the adjustment of the t_{off} parameters and
illustrates the influence of the different parameters. The
x-axis is the adjustable t_{off} parameter and the y-axis is the
resulting misalignment, Δt. The width of the horizontal bar 802
covering the x-axis defines the critical region $\Delta t_{critical}$, where
overlapping will cause problems.

The slanted bars of Fig. 8 show the timing relationship
to the neighbouring cells. One bar is drawn for each disturbing
signal, i.e. there are 4 bars $B_y \to M_x$ (804), $B_x \to M_y$ (806), $M_y \to B_x$
(808) and $M_x \to B_y$ (810) as appears from the above equations. The
thickness of each of the bars depends on the possible variation,
i.e the maximum propagation time in the cell containing the
mobile, t_r, and the tolerance of the synchronization signal,
Δt_{sync}. The difference between min (Δt) and max (Δt) is indicated
at 812 as $2t_r + 2\Delta t_{sync}$.

Vertical lines 814 and 816 extending through crossings
where the bars 804, 806, 808 and 810 meet the horizontal bar 802
indicate borders between "illegal" area 818 and "legal" areas
820 and 822 for t_{off}.

The geometrical adjustment procedure can be summarized as
follows, step by step.

    A.   Ordinary frequency planning.

This part of the procedure consists of the ordinary
planning, i.e.:

    - Distributing frequencies to cells;

    - Setting the parameters t_d, t_r;

    - Distributing the training sequences.

    B.   Find critical misalignments, $\Delta t_{critical}$.

Estimate an acceptable misalignment, e.g. $|\Delta t| > 5 \; T_s$.

C. Identify co-sequence layers.

The cells with particular training sequence codes TSCs
and equal frequencies are identified and treated independently.
Each group of cells with equal TSC will be referred to as a
TSC-layer.

D. Identify co-sequence cells with too little path loss
(i.e. causing disturbance).

For each cell co-sequence cells with a sufficiently low
path loss are identified. The path loss limit has to be
determined from measurements/simulations of TSC dependent
algorithms. E.g. Fig. 6 indicates that an examplary IRC
algorithm for uplink combining is very sensitive to co-
sequence interference, and therefore requires a high path loss.
A path loss of 30 dB more than the co-channel interference,
would make the effects from co-sequence interference comparable
to co-channel effects.

E. Find the geometrical parameters of the network.

The parameters are setup in a tabular form. Each cell is
linked to a group of cells, which are potential co-sequence
interfering cells. Find:

- The distances, d, between individual co-sequence cells;
- The radii, r, of all cells in the co-sequence layer.

F. Adjust time offsets between co-sequence cells.

The graphical overview is drawn for one cell with respect
to all the cells found as potential co-sequence cells. The time
offsets, t_{off}, are adjusted for this cell, and then all cells in
co-sequence tier one are adjusted, etc.... Tier is a ring of
cells to be explained below.

Below an example of the training sequence planning
procedure will be described, by explaining the required
steps A-F. The procedure results in a network design, which
ensures that all co-sequence interferers with too small path
loss compared to the path loss of the co-channel interferers,
will be shifted in time with respect to each other by a minimum
of 5 T_s. The example is based on the following assumptions:

1. Measurements/simulations have shown that the critical
overlapping area is $-5Ts < \Delta t < +5Ts$.

2. A co-sequence cell is disregarded, when the

propagation loss from it to the cell of interest is over 30 dB
more than the propagation loss from the co-channel cell to the
cell of interest.

   3. The frequency reuse factor is K = 1/1, so all
frequencies are used in all cells.

   4. The cellular structure is homogeneous, and the radius
of each cell is r = 500 m.

   5. The tolerance on the synchronization unit is Δt_{sync} =
1 T_s.

   Step A:

   Fig. 9 shows the presumed cellular network structure with
all frequencies reused in all cells, and only the 8 different
training sequences being used to distinguish between signals
from different cells. The digit within each cell corresponds to
a TSC-number used in the cell as indicated at 901 by arrows
pointing to two cells having the TSC-numbers 0 and 2,
respectively. The Figure also indicates two adjacent clusters
902 and 904 of cells, the borders of which are brought out by
thick lines, and which each contain 8 cells of equal size among
which the 8 possible TCS-numbers are distributed. In the whole
network structure, the 8 training sequences are distributed in
similar clusters.

   By a double arrow 906 the distance d between two co-
sequence cells 908 and 910, having the TSC-number 5, in the
clusters 902 and 904, respectively, is indicated. At 912 the
radius r of one of the cells is indicated within arrows. The
relation between the distance d and radius r is determined by
the equation $d = r\sqrt{3N}$,   N=8.

   Step A corresponds to the conventional planning of
frequencies and cell dimensions.

   In step B it is found by measurements/simulations that
the critical overlapping region is -5Ts< Δt < +5Ts.

   In step C the cells with the same training sequence
number are grouped together, into 8 different TSC-layers. The
clustering of sequences corresponds to the ordinary frequency
clustering, and the expression "tier" is therefore reused as
"co-sequence tier" in the case of co-sequence planning. Fig. 10
shows the geometry of one TSC layer, for TSC 3, similar to the
geometry of a frequency reuse clustering, there being a first

tier 1002 containing cells B-G, surrounding cell A, and a second tier 1004 of the TSC 3 layer.

In step D it is assumed that if a cell is so far away that the path loss is larger than 30 dB, its influence is insignificant as compared to ordinary co-channel interference. Power control and path loss have to be taken into account, when considering which cells have a sufficiently high power level to cause co-sequence problems.

When disregarding the power control, the difference between path loss of the desired signal and path loss of the co-sequence interference in the first co-sequence tier, can be calculated as $10\log(((d-r)/r)^{3.5}) = 21$ dB, in the worst case. The difference with respect to the second co-sequence tier becomes approximately $10\log(((2d-r)/r)^{3.5}) = 33$ dB. In this example it is assumed that only the first co-sequence tier is causing co-sequence problems, and the second one is attenuated sufficiently due to path loss.

The purpose of step E is to provide an overview in the form of a table or database, schematically illustrated by Fig. 11.

The table according to Fig. 11 in the first column contains all cells in the network which are to be time offset relative each other. Each of these cells is linked to a number of potential co-sequence interferers and their parameters, appearing in the second and further columns, respectively.

The table/database thus contains all the parameters in a linked way so that an iterative optimization program can start with row one, and go through the table until a solution is found. As the cellular structure is homogeneous, the table with linked cells also becomes homogeneous.

Step F starts the time adjustment procedure, following the table according to Fig. 11. First a graph according to Fig. 12 is drawn showing the relationship between cell A and the linked co-sequence cells B, C, D, E, F and G in the table. From Fig. 12 it can be seen that if no time offset is inserted, i.e. $t_{off(A)} = 0$ T_s, there is co-sequence interference present in the system. However by inserting a time offset of more than 10 T_s or less than -10 T_s, cell A will not transmit nor receive

co-sequence interference. The time offset for cell A, $t_{off(A)}$ is chosen to 10 T_s. In Fig. 12, the reason for this appears from vertical lines 1202 and 1204 extending through crossings where the slanted bars 1206 and 1208 meet the horizontal bar 1210, in the same way as has been explained for Fig. 8.

The adjustment of cell A is now finished, and cell A is avoiding all risks of co-sequence interference from co-sequence tier 1. The next step is then to adjust cell B to all cells in its first co-sequence tier, this being illustrated by the graph according to Fig. 13. Slanted bars 1302 and 1304 indicate possible Δt's for cells C, G, ... and slanted bars 1306 and 1308 indicate Δt's for cell A. The crossings between bars 1302, 1304, 1306 and 1308, on the one hand, and horizontal bar 1310, on the other hand, in this graph indicate the possible adjustment of the time offset for cell B, $t_{off(B)}$, in the same way as has been explained above with reference to Fig. 8. The co-sequence cell A has already been adjusted and is therefore shifted in the graph, as indicated by the location of bars 1306 and 1308. Cell A is in cell B's first co-sequence tier and the time offset $t_{off(B)}$ for cell B has to be higher than 20 T_s or less than -10 T_s as indicated by vertical lines 1312 and 1314 extending through the crossings where the bar 1306 and the bar 1304, respectively, meet the horizontal bar 1310.

The next step is to adjust the time offset $t_{off(C)}$ for cell C. Now there are two already adjusted cells, viz. cells A and B, in co-sequence tier 1 of cell C. Therefore the available space has been further reduced by 10 T_s. By considering the graph in Fig. 13 it can be seen that as much as 16 cells can be adjusted with respect to each other. In this example it is only necessary to adjust 3 cells to each other, as only the first co-sequence tier is taken into account.

The cell structure in this example has been homogeneous, since all cells are supposed to have the same dimensions. If this is changed, it will only involve some minor differences between the individual cells in the graphs. If d for example is increased with 1.1 km this will only correspond to adding one symbol time to Δt. There has furthermore been included a tolerance, Δt_{sync}, on the synchronization unit of ±1 T_s.

Furthermore, $\Delta t_{critical}$ has been set to be within the region [-5 Ts; +5 Ts], which probably is an overshoot as indicated in Fig. 6, where Δt isn't that critical for the values of 4 and 5 T_s.

In the solution of the example described above with reference to Figs. 9-13, it was possible to avoid co-sequence interference by using time offsetting. It may, however, be assumed that this will not always be possible, in case cell dimensions and power levels are very unbalanced. In such cases the solution may be to simulate the critical algorithms, as e.g. the IRC algorithm according to Fig. 6. The results obtained through such simulations can then be used to optimize the individual time offsets of the network up to a certain optimum point. The co-sequence effects will perhaps not be ideally avoided, as in the example described above, but they will be reduced to a satisfying level by minimizing the probability of critical co-sequence overlap, i.e. overlapping < $\Delta t_{critical}$.

In this situation the timing of the network is preferably optimized by setting up a cost function, as a function of time overlap and/or performance degradation.

Above, co-sequence interference has been discussed that can arise between co-channel cells having the same training sequence. The invention in this case is how to remove correlation effects from an undesired co-sequence interfering source. Problems with co-sequence interference can appear when tight frequency schemes are used, simultaneously using techniques exploiting correlation effects of the received signals. However, correlation problems can in addition occur due to the ordinary co-channel interference. The reason for the appearance of these degradations is that the different training sequences in GSM often are highly correlated. The present invention which so far has been described in connection with removing effects caused by co-sequence interference, can also be used successfully for removing undesired cross-correlation effects caused by ordinary co-channel interference.

With a few exceptions, the geometrical adjustment procedure using steps A-F described above can also be used for removing undesired cross-correlation effects caused by disturbing co-channel interference. A difference is that co-channel interferences in combination with training sequences

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with disturbing cross-correlation effects should also be adjusted in time to avoid overlapping in receiving units. It should be noted that the undesired overlapping region, referred to in Fig. 8 as $\Delta t_{critical}$, can be different for different pairs of training sequences.

The modifications to the procedure according to steps A-F described earlier are as follows.

In modified step B, the critical misalignments have to be found independen tly for different training sequences, i.e. there is a $\Delta t_{critical(x/y)}$, where x is the number of the desired training sequence, and y is the number of the interfering training sequence.

The table shown in Fig. 14 provides an example of found critical regions. In the table, the desired training sequence is supposed to be No. 0, as appears from the first term within brackets in all lines of the table. In the first row in the table, wherein also the interfering training sequence is indicated to be No. 0, compare the last term within the brackets, the co-sequence interference is shown to have the same critical region as in the earlier examples, namely -5 T_S < Δt < +5 T_S.

When the interfering source has training sequence No. 1, as appearing on line 2 of the table, compare the last term within the brackets, only overlapping for 0 T_S < Δt < +3 T_S has been found critical. However, if the interfering source has training sequence No. 7, as appearing on the last line of the table, compare the last term within the brackets, the algorithms of concern will not be affected by cross-correlation effects.

In modified step C, a group of potentially disturbing cells should be identified based on the size of the propagation loss. Fig. 15 shows an example of a cellular network structure in which the cells that are together bounded by thicker lines all may contribute with a sufficiently high power to cause correlation problems. The cell indicated at 1502 has the desired training sequence 0, whereas the cell indicated at 1504 has the co-sequence interference training sequence 0.

For each cell, all co-channel and co-sequence interfering cells which might interfere with a power, which is sufficiently

high to create undesired correlation effects, should be
identified.

In modified step D the group identified in modified step
C should be limited to cells having undesired correlation
effects. Referring to Fig. 16, illustrating the same cellular
network structure as in Fig. 15, these cells are the co-sequence
cell 1504 and a co-channel cell 1602 having training sequence
number 1 and indicated in line 2 in the Table of Fig. 14.

Following the above modified steps B-D, the procedure
continues along the same principles as described earlier for
steps E and F.

Thus, in step E the geometrical parameters of the network
should be found as described.

In step F adjustment of time offsets between co-sequence
cells is performed. The cells are adjusted one by one with
respect to the potentially disturbing cells found in modified
step D. The adjustment can be performed with the same
geometrical method as already described, however with different
critical regions for different interfering cells.

Fig. 17 schematically illustrates a radio base station
1700 for use in a cellular mobile radio system according to the
invention of the kind described above.

In Fig. 17 block 1702 indicates a switching unit being
connected, indicated by arrow 1704, to a network interface, and
to a local bus 1706. The switching unit 1702 includes a
function, indicated by block 1708, for receiving a time
reference signal, such as a synchronization signal from the
network or a base station time reference from an antenna
interface.

In a timing unit, indicated by block 1710, there is a
timing generator, indicated by block 1712, for receiving the
time reference signal from the time reference receiving function
1708. The timing unit 1710 also includes a store, indicated by
block 1714, for storing a radio base station specific time
offset of the kind that has been explained and described earlier
with reference to Figs. 7-16. As has been explained, this time
offset differs between co-channel radio base stations located in
the same cellular mobile radio base system by at least a
predetermined value which prevents known sequences in desired

signals and known sequences in interfering signals from
overlapping in a disturbing way at reception.

The time offset is received by the store 1714 via the
switching unit 1702 and transferred to the timing generator
1712. Via a timing bus 1716, the time reference signal and the
radio base station specific offset are received by transceivers
1718 communicating with the local bus 1706. The transceivers
1718 use the time reference signal and the radio base station
specific offset for the timing of sending bursts downlink
towards mobile radio stations via combiners and splitters,
indicated by a common block 1720, and an antenna interface, the
connection to which being indicated by a double arrow 1722.

Claims.

1. A method in a cellular mobile radio system including a
plurality of radio base stations and mobile radio stations,
said radio base stations using, as units of transmission,
bursts organized in groups, each group forming a frame of the
type used by a Time Division Multiple Access TDMA system, and
each burst containing a known sequence of data bits,
at least two of the radio base stations being co-channel
radio base stations employing a same frequency,
said method comprising the steps of
providing the co-channel radio base stations with a time
reference signal being a synchronizing signal or a time
reference from another co-channel radio base station,
providing each co-channel radio base station with a radio
base station specific time offset differing between the co-
channel radio base stations by at least a predetermined value
which prevents known sequences in desired signals and known
sequences in interfering signals from overlapping in a
disturbing way at reception,
using in each co-channel radio base station the time
reference signal and the radio base station specific offset for
the timing of sending bursts downlink from the co-channel radio
base stations towards mobile radio stations.

2. A method according to claim 1, wherein the steps of
providing a time reference signal and radio base station
specific time offsets comprise the substeps of
identifying within said cellular mobile radio system
cells having co-channel radio base stations, wherein there is a
risk that a co-channel mobile radio station in one of said cells
will come in sight of a co-channel radio base station in another
one of said cells,
synchronizing, by means of said time reference signal,
said co-channel radio base stations of said identified cells
while providing in each co-channel radio base station said radio
base station specific time offset as being a fraction of the
duration of a burst, but enough to prevent known sequences in

desired signals and known sequences in interfering signals from
overlapping in a disturbing way at reception.

3. A method according to claim 2, wherein the identifying
step includes identifying co-sequence cells employing the same
known sequence, making said interference problem a co-sequence
interference problem.

4. A method according to claim 3, wherein the step of
identifying includes grouping together the co-sequence cells
into layers including each only cells having a same known
sequence, and investigating said risk separately for each layer.

5. A method according to any of claims 2-4, comprising
disregarding, for each layer, cells having a power level too low
to cause said interference problem.

6. A method according to claim 4 or 5, comprising the
steps of determining successively, for each layer, the necessary
time offset·for each co-channel radio base station while taking
into consideration any time offsets already determined for other
co-channel radio base stations.

7. A method according to claim 6, comprising using as
parameters, for said successive determining step,

the distance between co-sequence cells,

the radii of the cells,

inaccuracy in the synchronization, contributing to
variation in the synchronization time.

8. A method according to any of claims 1-7, comprising
the steps of simulating disturbance and using the results
thereof to determine the radio base station specific time
offsets.

9. A cellular mobile radio system including a plurality
of radio base stations and mobile radio stations,

said radio base stations using, as units of transmission,
bursts organized in groups, each group forming a frame of the
type used by a Time Division Multiple Access TDMA system, and
each burst containing a known sequence of data bits,

at least two of the radio base stations being co-channel
radio base stations employing a same frequency,

said system further comprising

means for providing the co-channel radio base stations
with a time reference signal being a synchronizing signal or a

time reference from another co-channel radio base station,

means for providing each co-channel radio base station with a radio base station specific time offset differing between the co-channel radio base stations by at least a predetermined value which prevents known sequences in desired signals and known sequences in interfering signals from overlapping in a disturbing way at reception,

means enabling using in each co-channel radio base station the time reference signal and the radio base station specific offset for the timing of sending bursts downlink from the co-channel radio base stations towards mobile radio stations.

10. A system according to claim 9, wherein the means for providing a time reference signal and radio base station specific time offsets comprise

means for identifying within said cellular mobile radio system cells having co-channel radio base stations, wherein there is a risk that a co-channel mobile radio station in one of said cells will come in sight of a co-channel radio base station in another one of said cells,

means for synchronizing, by means of said time reference signal, said co-channel radio base stations of said identified cells while providing in each co-channel radio base station said radio base station specific time offset as being a fraction of the duration of a burst, but enough to prevent known sequences in desired signals and known sequences in interfering signals from overlapping in a disturbing way at reception.

11. A system according to claim 10, wherein the identifying means include means for identifying co-sequence cells employing the same known sequence, making said interference problem a co-sequence interference problem.

12. A system according to claim 11, wherein the means for identifying include means for grouping together the co-sequence cells into layers including each only cells having a same known sequence, and means for investigating said risk separately for each layer.

13. A system according to any of claims 9-12, comprising means for finding, for each layer, cells having a power level too low to cause said interference problem, and disregarding

such cells.

14. A system according to claim 12 or 13, comprising means for determining successively, for each layer, the necessary time offset for each co-channel radio base station while taking into consideration any time offsets already determined for other co-channel radio base stations.

15. A system according to claim 14, comprising using as parameters, in said succesive determining means,

the distance between co-sequence cells,

the radii of the cells,

inaccuracy in the synchronization, contributing to variation in the synchronization time.

16. A system according to any of claims 9-15, comprising means for simulating disturbance and using the results thereof to determine the radio base station specific time offsets.

17. A radio base station for use in a cellular mobile radio system including a plurality of radio base stations and mobile radio stations,

said radio base stations using, as units of transmission, bursts organized in groups, each group forming a frame of the type used by a Time Division Multiple Access TDMA system, and each burst containing a known sequence of data bits,

at least two of the radio base stations being co-channel radio base stations employing a same frequency,

said radio base station comprising

means for receiving a time reference signal,

means for storing a radio base station specific time offset differing between co-channel radio base stations by at least a predetermined value which prevents known sequences in desired signals and known sequences in interfering signals from overlapping in a disturbing way at reception,

means for making use of the time reference signal and the radio base station specific offset for the timing of sending bursts downlink from the co-channel radio base stations towards mobile radio stations.

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FIG.1

FIG. 2

FIG.3

FIG. 4

Sector MRC cosequence versus cochannel

FIG.5

ASTA IRC cosequence versus cochannel, TSC=2

FIG.6

FIG.7

FIG.8

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$$d = r\sqrt{3N}, N=8$$

FIG.9

FIG.10
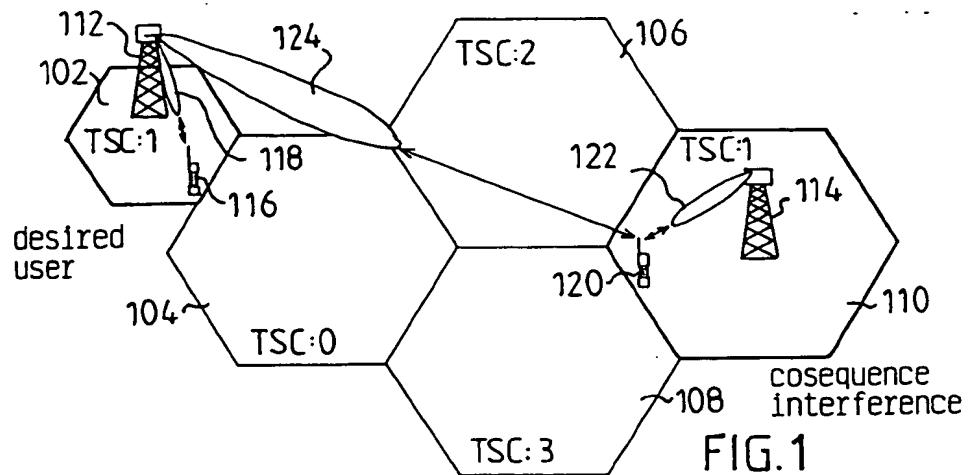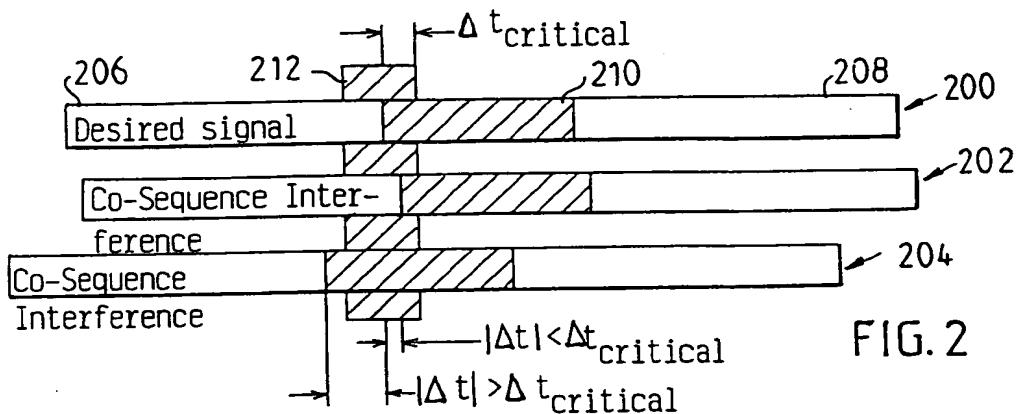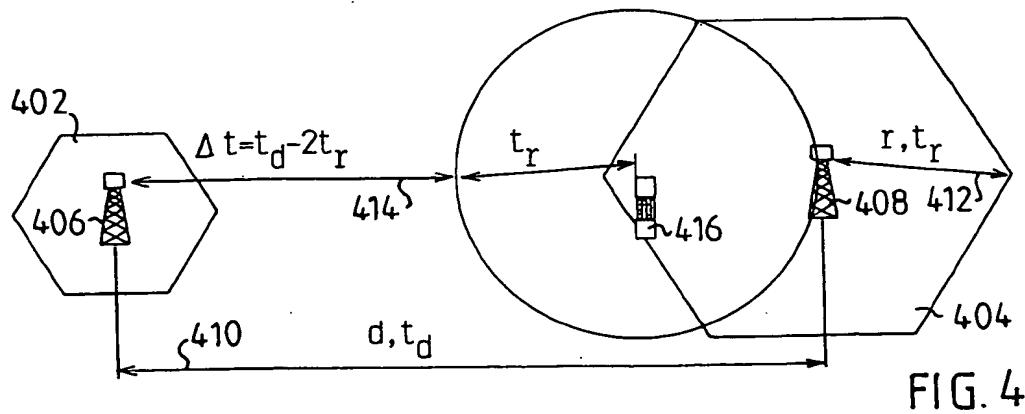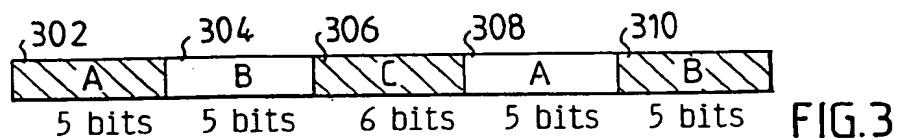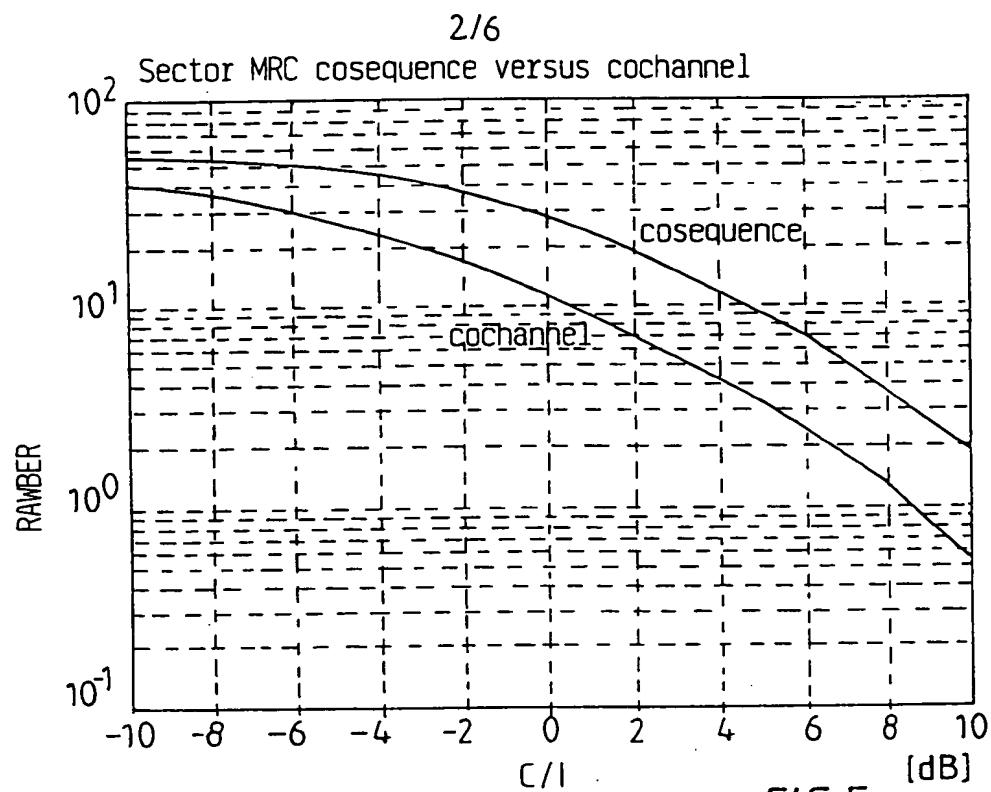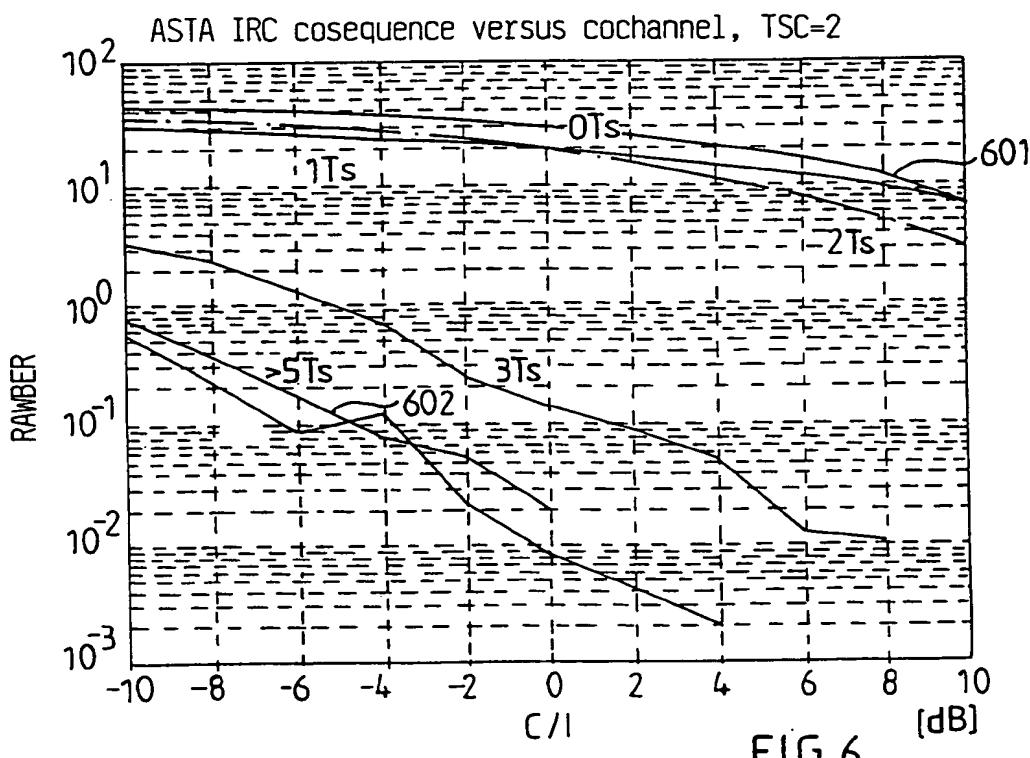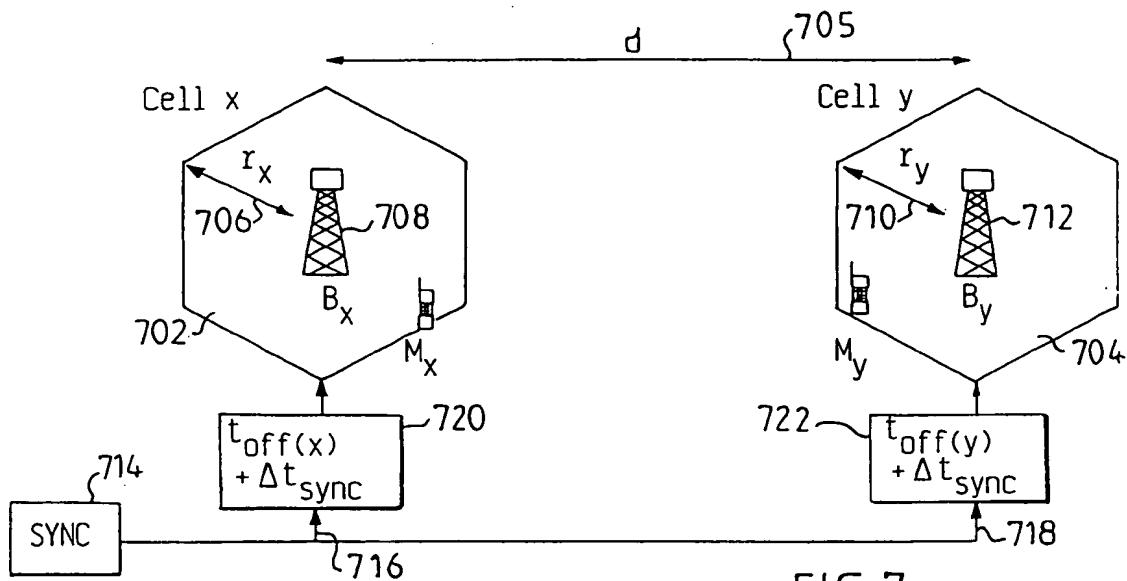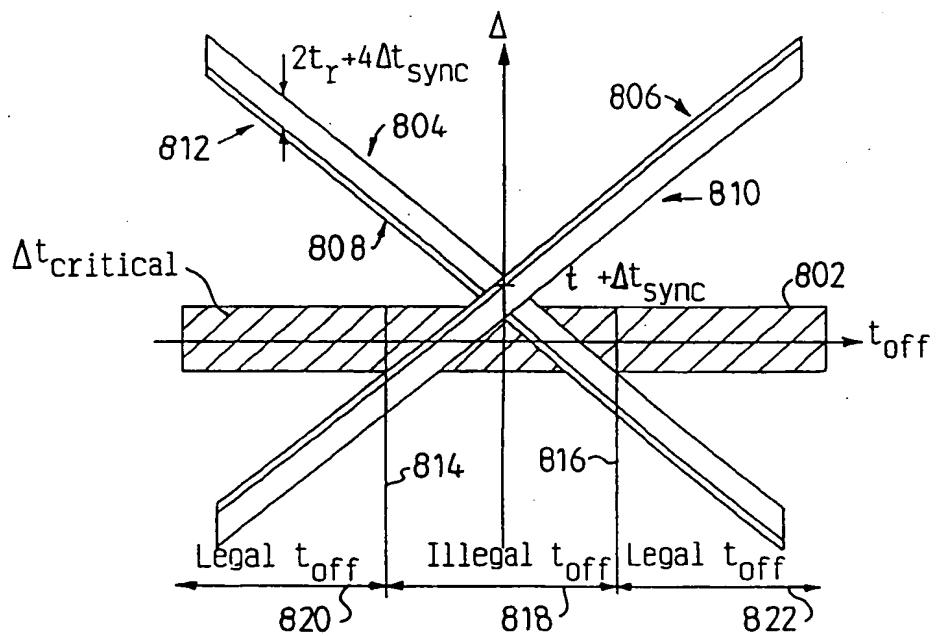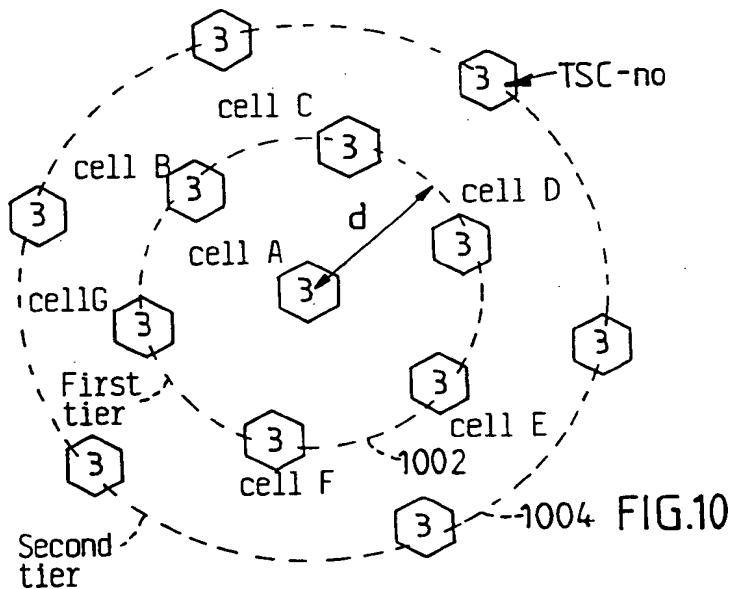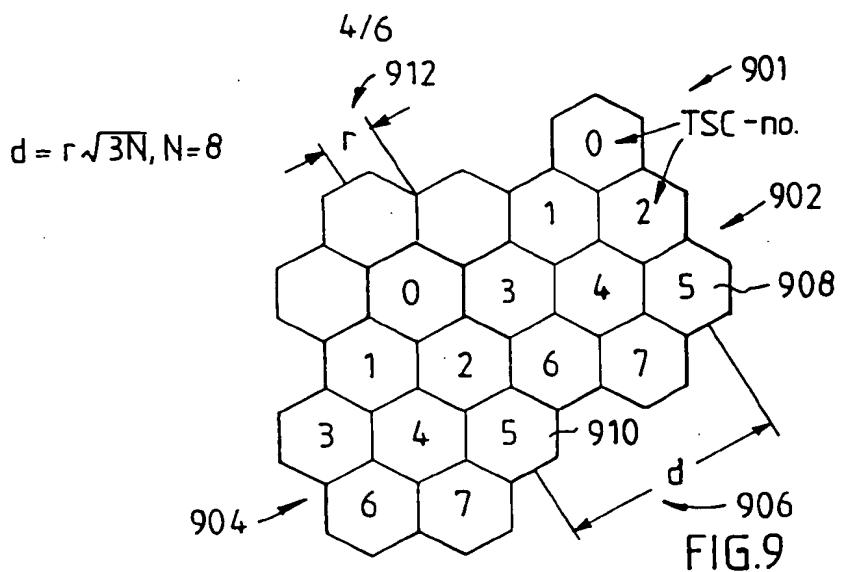
Cell to Adjust	Co-sequence Cell	Inter Cell Distance, d	Cell Radius, r
Cell A	Cell B	2449 m	500 m
(r_A=500m)	Cell C	2449 m	500 m
	...	...	...
	Cell G	2449 m	500 m
Cell B	Cell A	2449 m	500 m
(r_B=500m)	Cell C	2449 m	500 m
	...	...	...
...	...	...	...

FIG.11

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FIG.12

FIG.13
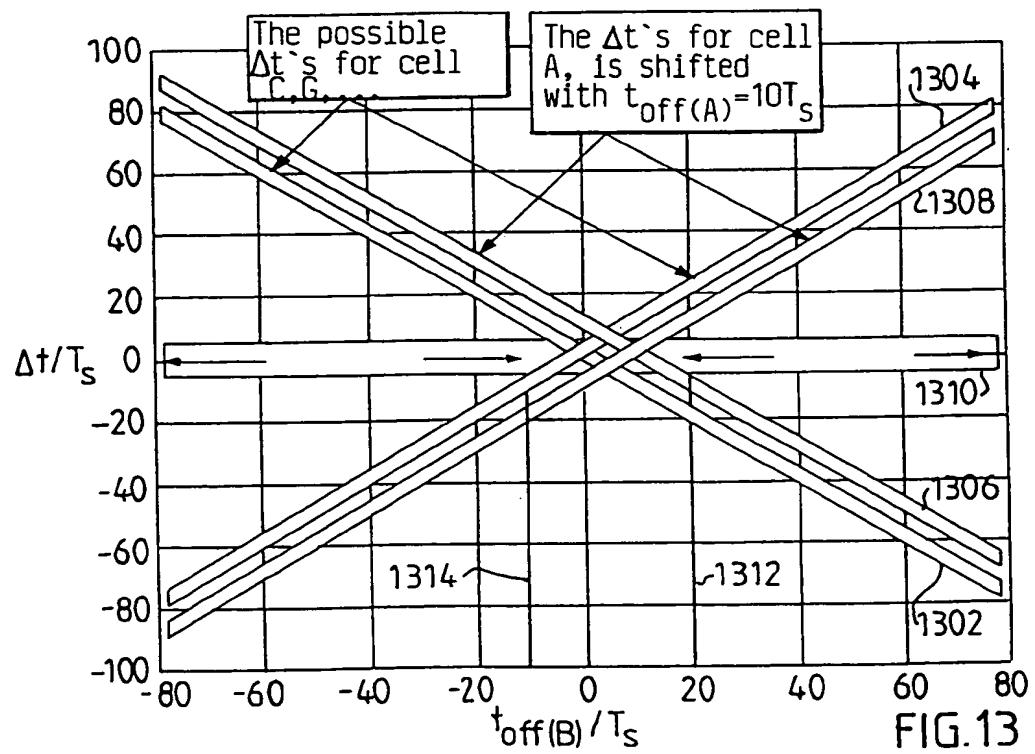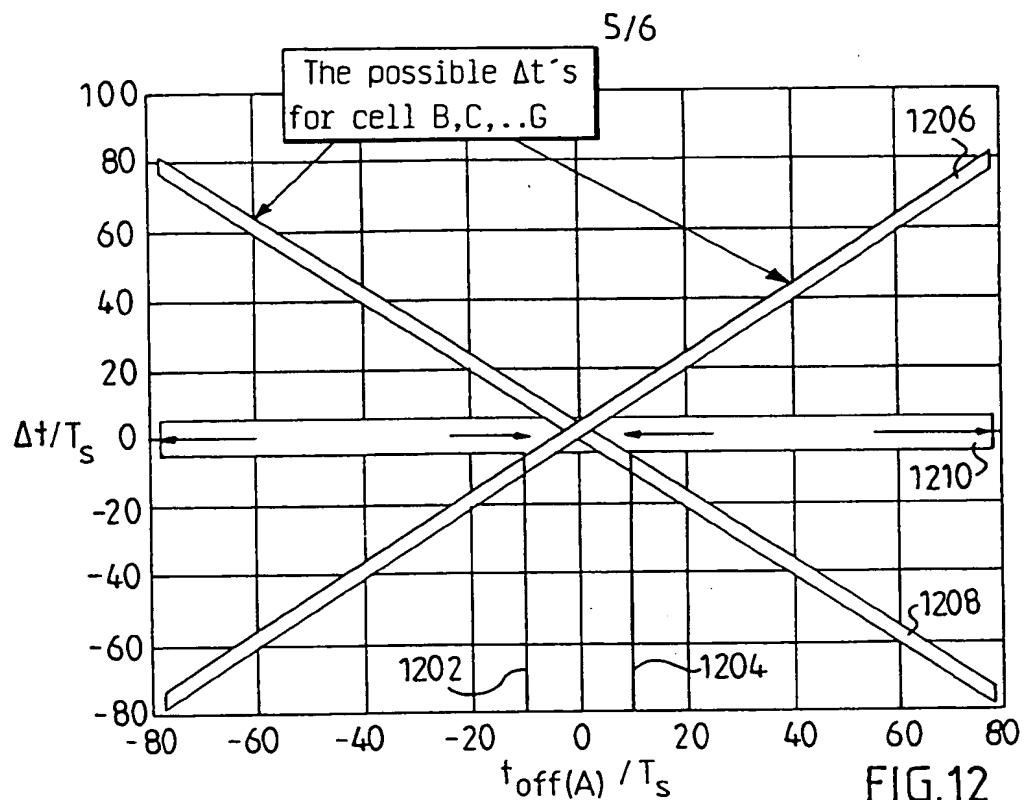
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$\Delta t_{critical(0/0)}$	$-5T_s < \Delta t < +5T_s$	co-sequence interference
$\Delta t_{critical(0/1)}$	$0T_s < \Delta t < +3T_s$	cochannel interference
$\vdots$	$\vdots$	cochannel interference
$\Delta t_{critical(0/1)}$	not critical	cochannel interference

FIG.14
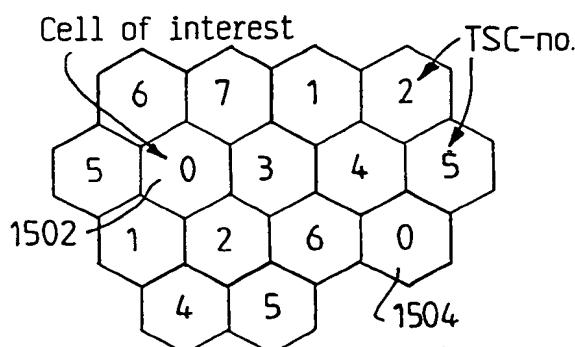
FIG.15
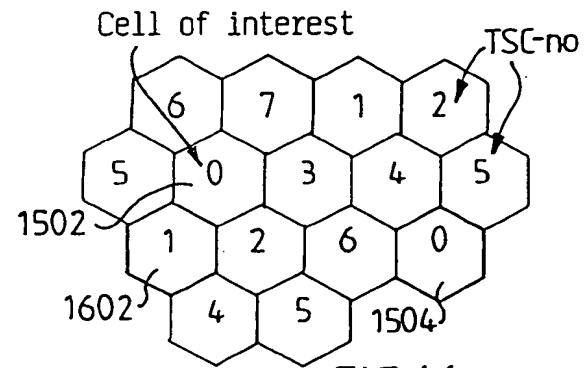
FIG.16
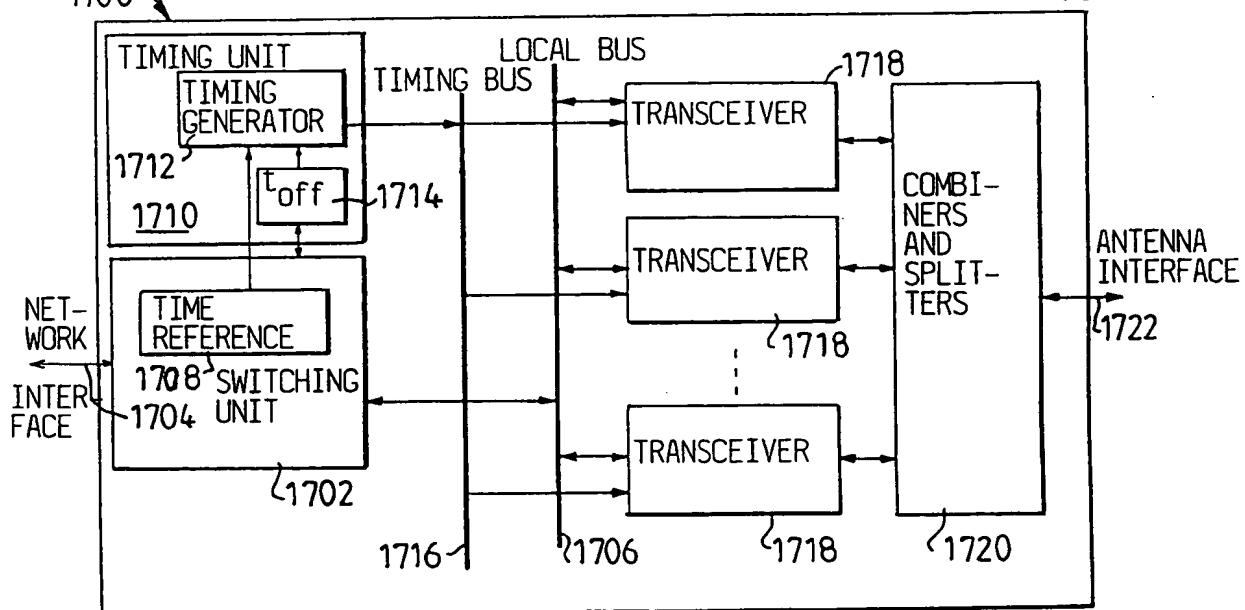
FIG.17

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/26, H04J 3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04Q, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPAT, WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5684794 A (ALFRED R. LOPEZ ET AL), 4 November 1997 (04.11.97), claim 1, abstract	1-17
A	US 5519710 A (SHIGERU OTSUKA), 21 May 1996 (21.05.96)	1-17
A	US 5440561 A (ALTON P. WERRONEN), 8 August 1995 (08.08.95)	1-17
A	US 5177740 A (RAYMOND L. TOY ET AL), 5 January 1993 (05.01.93)	1-17

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 1998	2 7 -11- 1998

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01231

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0173348 A2 (NEC CORPORATION), 5 March 1986 (05.03.86)	1-17
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A	Patent Abstracts of Japan, abstract of JP 7-203543 A (NIPPON TELEGR 6 TELEPH CORP), 4 August 1995 (04.08.95)	1-17
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US	5519710	A	21/05/96	EP	0626769	A	30/11/94
				JP	6338847	A	06/12/94
				JP	2526803	B	21/08/96
				JP	7154849	A	16/06/95
US	5440561	A	08/08/95	NONE			
US	5177740	A	05/01/93	CA	2076107	A	04/03/93
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				CA	1243788	A	25/10/88
				JP	1614074	C	15/08/91
				JP	2028931	B	27/06/90
				JP	61060022	A	27/03/86
				US	4688217	A	18/08/87
				JP	1614075	C	15/08/91
				JP	2028932	B	27/06/90
				JP	61060023	A	27/03/86